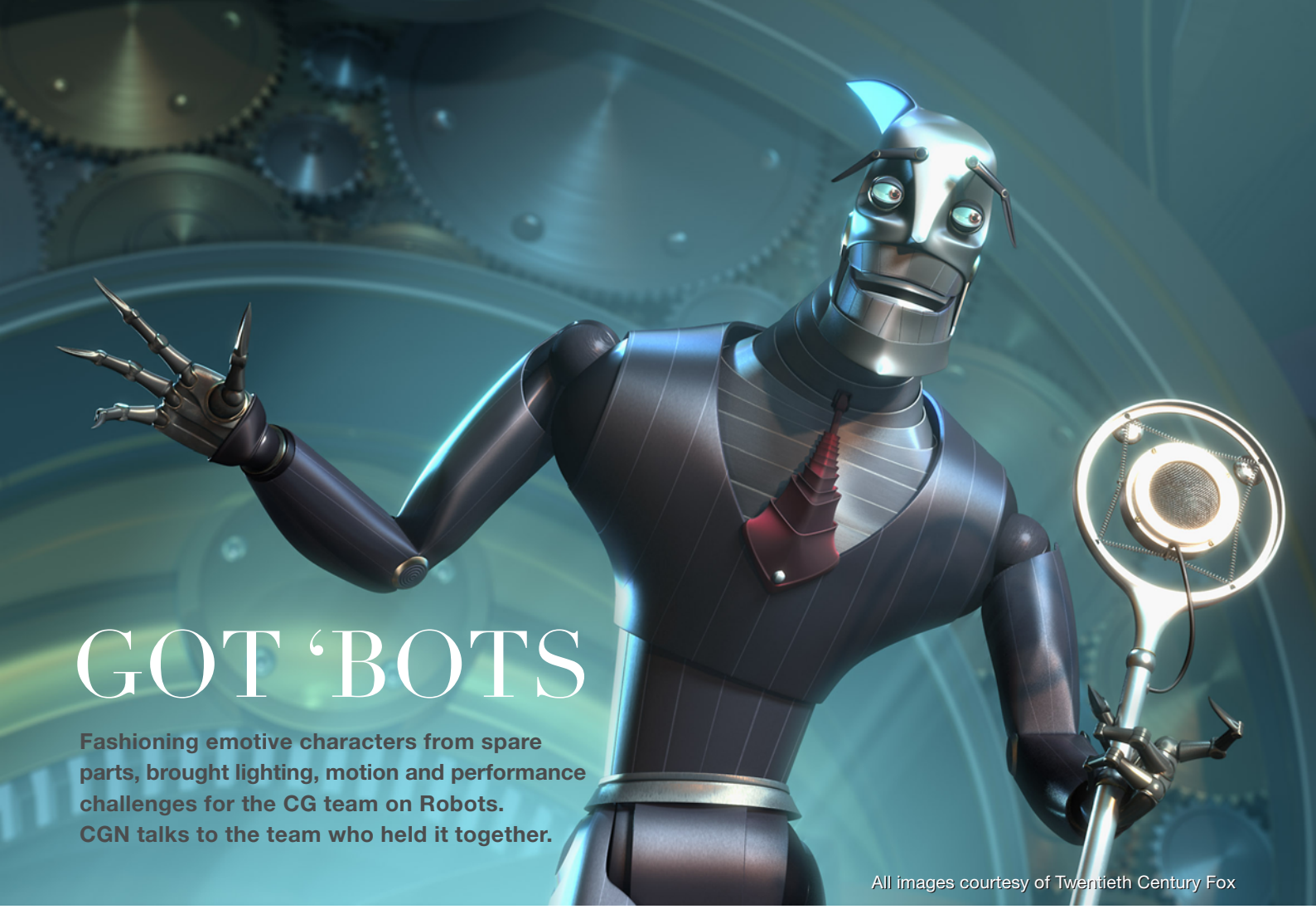


GOT 'BOTS

Fashioning emotive characters from spare parts, brought lighting, motion and performance challenges for the CG team on Robots. CGN talks to the team who held it together.

All images courtesy of Twentieth Century Fox

CGNetworks Feature :: Robots
Barbara Robertson, 27 April 2005

With a body fashioned after an Evinrude outboard motor, Rodney Copperbottom, the hand-me-down son of a dishwasher and star of Fox/Blue Sky Studios' comedy-adventure Robots, takes animation fans on a riveting ride. Directed by Chris Wedge and Carlos Saldanha, the feature film stars the voice talent of Ewan McGregor as Rodney, and Robin Williams as Rodney's rusty friend Fender.

Robots flaunts the animation and storytelling skills of the studio that created the Oscar-nominated movie Ice Age, the Oscar-nominated short film "Gone Nutty," and the Oscar-winning short film, "Bunny." And shining through Robots' quirky mechanical, glass and metal world, is CG technology honed since the studio was founded. Well, almost everything shines. Because Robots references the past 100 years of industrial design, some of the machines are a bit rusty.

The technical challenges for the studio were in rendering a visually complex world made entirely of glass and metal with a physically accurate raytracer, giving the "outmodes," the rusty robots made from hand-me-down parts, surface textures that wouldn't choke the pipeline, and in crafting mechanical people capable of emotional performances without deforming the metal.

"We didn't want to go into the making of Robots with any preconceived constraints," says Carl Ludwig, director of R&D. "Chris Wedge always wanted the feeling of a fantasy world. We had to invent ways to deal with the number of characters, the complexity of modeling and building cities, and we wanted to show how far we could take the rendering, our forté."

Nuts and Bolts

Two types of robots populate Robot City, old, industrial robots, many cobbled together from spare parts, and shiny modern robots. Spurred by his mother Madame Gasket (Jim Broadbent), the newest and shiniest 'bot of them all, Ratchet (Greg Kinnear), has taken over Big Weld industries. Big Weld himself (Mel Brooks), champion of inventors and friend to the outmoded Rusties, languishes in his old lab playing dominoes. In order to sell new robot chassis, Ratchet stops manufacturing spare parts and sweeps up any "outmodes" on the street for his mother to melt down. Rodney, the young, budding inventor, saves the day with help from the Rusties and a new 'bot named Cappy (Halle Berry).

"We had a lot of fun learning how to make these characters warm and appealing, but still be made of metal and sound like metal," says Wedge. In the beginning they tried to keep the robots purely mechanical, but eventually added deformations and squash and stretch to give them a more emotional performance.

For example, Rodney's eye sockets have an outer casing that deforms to help make him appear more lifelike, and deformations were also used for robot lips. Fender's eyebrows, made from windshield wipers, bend, and newer 'bots made of sheet metal had more deformations than the heavy metal ironworks. But most of the animation was based on rotations and translations. To imitate squash and stretch, the robots' arms could extend and retract like pistons; Rodney had a spring between his pelvis and upper torso.

"It was tricky to animate brows and eyes because they weren't attached to the skull," says David Torres, lead animator. "Every body part had a mover." Usually when an animator moves a character's eyebrow, a rippling effect in the forehead and cheeks adds expression. For the 'bots, the animators had to move all the parts individually.

"We had to respect their mechanical aesthetic," adds Galen Chu, lead animator. "We couldn't create any shape we wanted. They had to look plausible within their designs, so we had to do a lot of searching to create what looked right with our characters."

Parts, We Got Parts

The robot bodies were created with subdivision surfaces that were rendered as Bezier patches, not polygons, not NURBS.

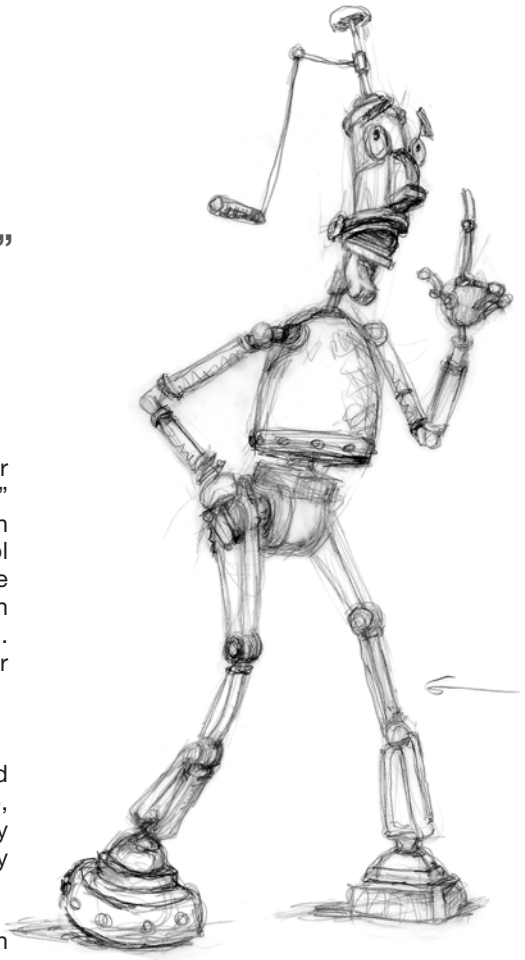
"The usual reason to use subdivision surfaces instead of NURBS is that it's easier to make organic models," says researcher Maurice Van Swaaij. "But, in Robots, we had a lot of difficult machine parts and those are also hard with NURBS. Each part might have taken a whole set of NURBS. When you glue NURBS patches together, it's hard to keep seams from showing. But with subdivision surfaces you can have an arbitrary topology. It doesn't matter how many holes or handles the model has and because it's one surface, you don't have to worry about gluing pieces together."

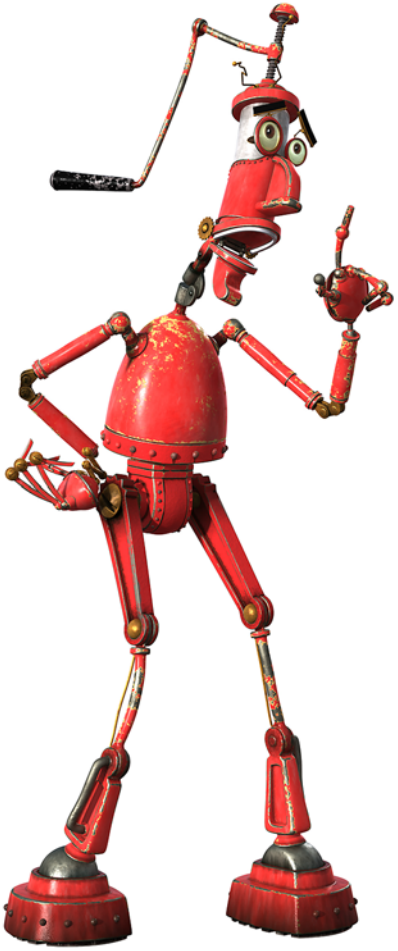
To create crowds of mechanical people and to populate the cityscape with buildings, the researchers created a back lot system of parts and pieces. "Frankenbots" were randomly generated from selected parts and buildings were constructed procedurally as well. Even the main characters, much like the Rusties in the film, were made from spare parts.

"We'd break out parts that could be re-used," says Michael DeFeo, modeling supervisor. "As the back lot built up over time, we'd get to a new character, and say, 'that wingnut would work very well.'"

The subdivision surfaces were converted to Bezier patches for rendering because their curved surfaces didn't have to be subdivided to achieve a smooth shape. Often, that creates a problem, but not for this studio.

“It’s a complicated movie. Nothing in it exists strictly speaking in our world. No trees, clouds, bushes, houses.”



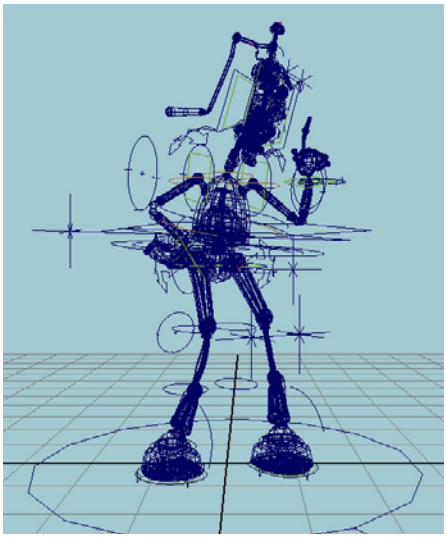


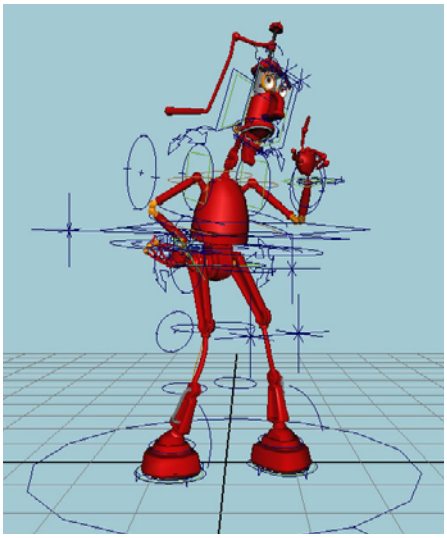
“The problem is that rendering Bezier patches with ray tracing is difficult,” Van Swaaij says. “You have a ray in space and a patch with 16 control points on an arbitrary shape in space and you have to figure out where in space that line intersects the patch. Fortunately, we had tracking to Bezier patches already.”

Creating Textures on the Fly

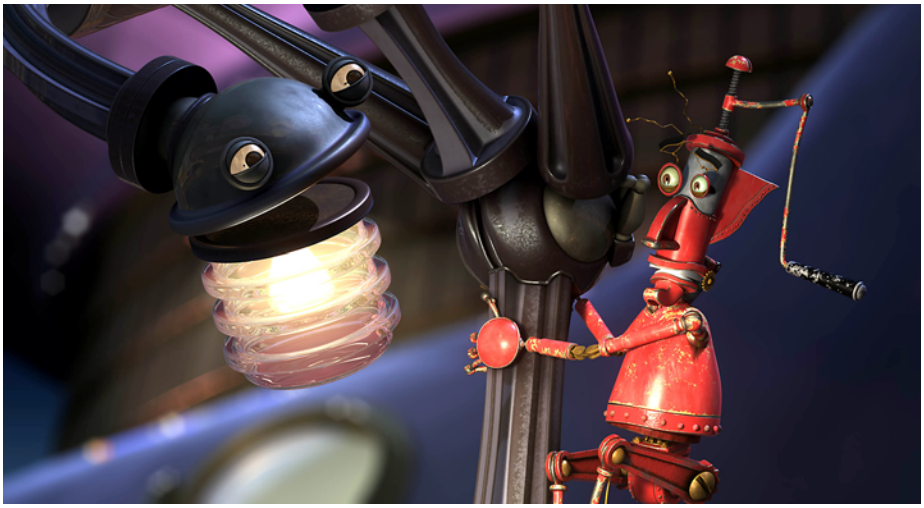
Using subdivision surfaces created another problem: No UV space. So, the question became: How would they texture the models? The answer they devised solved two problems, not one.

“We realized early on that the rich surface textures and complex materials we wanted on the buildings and on the characters would be a problem with standard mapping techniques because of memory limitations,” says Ludwig. “So we came up with new ways that are mostly procedurally based to interactively create materials on surfaces.” That reduced the amount of memory needed and it had another advantage: The team didn’t have to deal with UV spaces.





The procedural system the crew developed uses Maya’s node editor to set up materials and then it bypasses Maya. “We’re using Maya mostly for the GUI,” Van Swaaij says. “We even wrote a lot of the nodes ourselves.” Each node represents a processing unit that might be, say, a noise function, an interpolation between colors, or perhaps a distance to a point. “With a lot of procedural shaders that are based purely on noise functions, you have limited control, but in our system, you can manipulate the materials in the way you want by placing control points and shapes in space that make the material appear. The material is defined in the entire space, but evaluated only on the model. It’s a paradigm shift.”



Once the material is defined it can be previewed in Maya before it’s compiled into C++ code and rendered with Blue Sky’s proprietary CGI Studio software. “Compiling is essential,” says Van Swaaij. “Nodes are great for TDs, but when you’re rendering, you need pure code.”

Shine whatever you're made of
One of the problems with lighting a metallic world with a ray tracer was in controlling the reflections, the diffuse light and specular highlights. The new 'bots are made of shiny metal that has close patterning and graining. The older 'bots have flaky paint. They react differently to light, and both are often in the same environment. In addition, some buildings reflect light; others don't.

"We don't use environment maps," says Dave Esneault. "We use the environment. It took a while to know how much changing the light on, say, a toaster would affect the lighting on a character. People were cranking diffuse too much at first, which made the less reflective objects over lit. We had light bouncing everywhere."

As Big Weld puts it, "You can shine no matter what you're made of."

From domino effects created with choreographed and keyframed wave shapes and particles, to fountains spewing oil that was created with fluid dynamics, to thousands of procedurally animated ball bearings, to a city that looks like the inside of a watch and lamp posts that go home in the morning, Robots is a complete whimsical, energetic world that could have been created only with CG.

"It's a complicated movie," says Wedge. "It's dense. There's a lot of character acting, a lot of action, and in every shot there's a lot to look at. The thing that we finally understood about Robots was that we needed to make a complete fantasy world. Nothing in it exists strictly speaking in our world. No trees, clouds, bushes, houses. What was inspiring to me in a nerdy, 'this is cool' way, was that we managed to render a fairly complete world that tricks you, convinces you, that you're actually there when you couldn't possibly be."

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